A Discussion of NREL Pilot Projects in China

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Abstract

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In the coming years, China's energy consumption will likely rise dramatically. Renewable energy technologies can relieve the pollution that would be caused by the use of conventional fossil fuels and bring electricity to rural populations. The National Renewable Energy Laboratory (NREL) has been actively promoting renewable energy in China. NREL has participated in several pilot projects in China. The ones that will be discussed are the Inner Mongolia Autonomous Region Wind/PV Hybrid Home System project, the Gansu Solar Home System project, the XiaoQingDao Wind/Diesel Hybrid Island Power project, the Tibet PV village project and the Geothermal Heat Pump project. Topics that concern these pilot projects are financing, post-installation maintenance, project review, cultural consideration and community involvement.

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Introduction

In 1995, the United States signed a bilateral agreement with China with the goal of encouraging the use of renewable energy in China. Since then, the National Renewable Energy Laboratory (NREL) has been involved in helping China promote renewable energy as a viable source of power. In addition to providing training, business development, information exchange, and analyses of resource potential, policy incentives, and market potential, this program has sought to demonstrate renewable energy technologies in China through implementation of pilot projects. Pilot projects are small-scale projects to install a new technology in order to gauge the effectiveness of this technology. One of the main goals of a pilot project is to provide a working example of renewable energy and introduce renewable energy technologies through technology transfer. Pilot projects can accomplish many tasks such as rural electrification and public education about renewable energy technology. They are also a good way of testing the performance and suitability of a system or a distribution mechanism in a certain community. Pilot projects present an opportunity to create a favorable impression of renewable energy among the population in a country that is the number one global consumer of coal and gets 75% of their energy from coal. China is a rapidly developing country that will require more and more energy. Using alternative energy sources is essential to cutting down pollution. The popularity of renewable energy relies on satisfied users spreading the word to the people around them.

Many factors determine the outcome of a project. Some topics that should be considered are the sustainability of a system, financing, post-installation activities, cultural differences and community involvement. These factors should be carefully

thought out in the design phase of a project. After completion of a project, an analysis of the experiences gained in each area will be beneficial to future renewable energy work. This paper reviews several pilot projects NREL has launched in China, their strengths and shortcomings.

The Projects

The five China pilot projects that will be discussed are the Inner Mongolia Autonomous Region PV/Wind Hybrid Home Systems Project, the Gansu Province Solar Home Systems Project, the ShangDong XiaoQingDao Wind/Diesel Island Power System, the Tibet Solar Home Systems and PV Village and the Geothermal Heat Pump project.

Inner Mongolia Hybrid Home Systems

The Inner Mongolia PV/Wind Hybrid Home System Project began in 1995 as a collaboration between the Department of Energy (DOE) and the Chinese Ministry of Science and Technology. Although wind power had been widely used in the area since 1980, the systems were unreliable during the summer months when wind resources were low. A case study was done to see what the best systems for the region would be considering costs and resources. A PV/Wind/Battery hybrid system was determined to be the most reliable and cost effective system for this particular region. Wind resources in Inner Mongolia are among the richest in China during winter but die down during the summer season. However, solar energy resources during the summer are quite high and can supplement the lower wind energy. Also deep cycle batteries that are designed to handle long discharge periods replaced the automotive batteries that were previously

being used. Automotive batteries were not suited for this kind of system because they are designed to withstand long discharge periods and tended to die completely rather quickly. By 2000, 96 home systems were installed with Chinese components and 243 home systems were installed with US PV panels and Chinese wind turbines and balance of systems. Beneficiaries paid for the systems with the help of a credit program. They paid for half the cost of the system upfront and half later when they had generated more income. The returns were used to establish a revolving fund to aid future home system purchases. This has led to plans of Dongwu county for another 4000 systems and pioneered technologies that will now be used by the provincial and state governments for 50,000-60,000 systems over the next 5 years.

Gansu Solar Home Systems Project

In Gansu, an agreement was made between the DOE and the Chinese Ministry of Agriculture for a rural electrification project using renewable energy technology. The plan was to install 1000 solar home systems (SHS) in the Gansu province in three years. A revolving fund and cash sales would be used to help future SHS purchases. The project was delegated to NREL. The Solar Electric Light Fund (SELF), an NGO, was subcontracted by NREL to implement and manage the project as well as oversee the buying of equipment. On the Chinese side, Gansu Solar Electric Light Fund was given responsibility for the project. GSELF subcontracted three Chinese companies, Gansu Natural Energy Research Institute (GNERI), Zhong Xing PV Electricity Company (ZXPV) and Gansu PV Electricity Company (GPV) to install the systems. PV solar systems were installed in 320 homes and 10 schools by 1998. In most of the counties,

local technicians were trained and available to provide maintenance for the systems. Also, surveys were conducted after the systems were installed in order to gather data about user satisfaction, system performance and maintenance support. Gansu Solar Electric Light Fund installed an additional 460 PV systems and a revolving credit fund was set up by this project. The Ministry of Agriculture has now expanded its solar home system project to 10,000 households in 6 provinces. The Solar Electric Light Fund is now completing two PV school systems.

XiaoQingDao ShangDong Island Project

Providing power to a small island was the idea behind the XiaoQingDao ShangDong project. A large-scale Wind/Diesel hybrid system was installed. Individual home systems can provide power for lights, TV, radio, and so forth, but village power systems can provide AC power that can be used for motor-driven equipment and productive uses. The US side provided four 10kW America wind turbines from Bergey, 160 batteries and a 40kW inverter. The Chinese side provided a 30 kW diesel generator, batteries and the grid connection. This system provides 40kW 24 hours a day to 123 homes and about 350 island inhabitants. Although the end-users did not contribute to the installation and systems costs, they pay a user fee for receiving the electricity. Before this system was installed, an old 13kW diesel generator provided electricity to the island for only 4 hours a day. Since the diesel fuel was expensive, the user fee that users pay now for the hybrid system is lower than the fee they paid for the diesel generator. These are some benefits of wind power that the inhabitants of the island can see directly. Since the island is located close to mainland, the system is highly visible.

Tibet Solar Homes and PV Village

The Tibet Solar Homes and PV Village was a project that stemmed from an agreement between the local government and the DOE and the Asia Pacific Economic Cooperation staff to install 6kW of power in the area. The first phase of the project was dedicated to installing solar home systems in rural villages. Two Nepalese companies, Lotus Energy and Wisdom Light Group, installed around 200 home systems, a total of 1.4kW. Users made a one-time payment of 50yuan for their systems. A revolving fund was established from these payments but was quickly depleted to cover initial costs.

The next phase of the project is to construct a PV village system that will power computers, video equipment and other accessories. This part of the project focuses on setting up a sustainable business. The village can use this power and equipment to make videos of various aspects of Tibetan life – from ceremonies to the landscapes. They can then sell these videos via the Internet to generate income.

Geothermal Heat Pumps

The Geothermal Heat Pump project began in 1997 as an agreement between the Chinese Ministry of Science and Technology and DOE. The goal was to disseminate American Geothermal Heat Pump technology, which uses ground-air heat exchange, throughout China. There are three phases of this project. Phase I, the construction of three demonstration projects, was completed in 2001. These buildings, which incorporate GHP as a means of temperature control, have been built in each of the major climate zones – the cold north, the mild central area and the hot south. The cold north building is

in located in Beijing and is a luxury apartment building. The other two projects are a 5 building complex in Ningbo City of the Zhejiang Province and a classroom building in Guangzhou City in Guangdong Province. Phase II of the project is the joint promotion of GHP technology through the construction of systems in many different climates for varying uses and in a wide variety of buildings. During this period there will be an emphasis on improving design capability, technical training and economic and technical analyses. In Phase III, Chinese firms will be selected to launch jointly funded production with the goal of lowering production costs and improving localization. The Chinese government will lend limited support but the firms will operate in a strict market mode in the hopes of preventing the sale poor quality GHPs and to lay down a strong reputation for GHPs. Less information is available for these pilots as they have only recently been installed.

Sustainability Issues

In designing and implementing pilot projects, some questions to consider are: How will end-users pay for the products? How will these systems be delivered, managed, maintained? What are good ways to introduce this renewable energy market and keep it alive after the project is finished? Using the five pilot projects briefly mentioned above, the following topics: financing, maintenance, post-installation analysis, cultural considerations and community involvement will be discussed.

Financing

The financing aspect of a project is key to long-term success. Each of these projects had a different approach to financing. Inner Mongolia had a successful financing program. The payment plan was simple. Only two payments were involved. End-users paid a part of the cost when they purchased the system and the rest half a year later. The money from the payments went back into a revolving fund. The revolving fund was used to subsidize part of the initial payment of future home systems. This way, households can continue to install renewable home systems. It must be taken into consideration that the residents in Inner Mongolia are relatively wealthy and are, perhaps, better able to afford the systems. Most of the income comes from selling cattle, sheep, cashmere and wool, which draws in an average of 2000RMB a year.

The Gansu project had a less successful financial plan. Many end-users received large subsidies on the initial cost of the SHS, some as much as 85%. In the TianZhu County, end-users paid 400yuan for 1500yuan systems. The finance plan was unclear and many end-users were unaware or did not understand that they had to repay the remainder of the cost. Therefore it was difficult for the project organizations to recollect the money intended for the revolving fund. Sometimes, the organizations found that the cost of collecting payments was more than the value of the payments themselves. This highlights the need to ensure that enough systems are installed in a geographically tight enough area to make a viable business operation. Being unable to retrieve costs harms the future of a revolving fund, which is designed to help subsidize for future purchases of home systems. If the amount being returned to the revolving fund for each system is less than the money taken out, then the fund will have a short lifespan. The PV market in the area

will also be damaged because the beneficiaries who received heavily subsidized system will have an impression that the amount of money they put into the system initially is the general cost of PV systems. This will make it difficult for businesses to establish themselves and sell PV systems profitably.

In Tibet, a revolving fund was also established with the purpose of perpetuating the PV market going. The total amount collected from end-users to pay for the systems was only 50yuan. However, the systems themselves are worth much more than 50yuan. The money collected was put in a revolving fund but it was depleted almost immediately to pay for initial expenses. This left the fund unusable for the initial intended purposes of subsidizing future purchases of PV home systems, providing for maintenance and spare parts.

Maintenance

Ensuring that a system continues to be productive after installation should be an important aspect of the project. If the purpose of a pilot project is to provide a working example of renewable energy as a power source, then it is necessary to see that the system continues to operate correctly after installation. In many of the pilot projects, this has not been taken into consideration fully.

In the Tibet project, the revolving fund was not established correctly and there was little money available for maintenance of the SHS's. When systems broke down, the end-user often had to find a Chinese solar energy shop to buy new parts or have a system repaired. Since many of the beneficiaries were quite poor and couldn't afford maintenance, they did not attempt to repair the system. In Inner Mongolia, there are

government support centers where owners can take their systems to be repaired. Also, many of the commercial shops offer warranties with the systems so buyers have a place to take them for maintenance. For the Gansu project, technicians within the community were trained in the care and maintenance of the systems and were able to service the systems. Also, the three organizations that installed the systems also offered repair services to the beneficiaries. With regards to the geothermal project, most of the buildings were just completed in 2001 so there are not many reports regarding their maintenance as of yet.

Post-installation Analysis

Not only are pilot projects a demonstration of renewable energy technology, they are also a means of testing out new ideas. With pilot projects, one can study how a particular technology, system, financial mechanism, etc. works for a certain community or area. Therefore, post-installation surveys and analysis should be an integral part of the project design. The surveys can be used to find out the end-users response to the systems, whether the system or financial mechanism was appropriate for the community and whether the technology was beneficial and will have an opportunity to spread to surrounding areas. It is not necessary to have a standard for success outlined for these projects but these pilot projects should be viewed as a way of learning about how to approach the introduction and use of renewable energy technology in future work. It is important to identify areas of the pilot projects seemed successful and areas that needed improvement, so as to not repeat the same mistakes.

In many of the pilot projects in China, there have been no post-installation analyses. Only in Gansu and Inner Mongolia have there been a continuous output of project reviews and result reports. Also, only in Gansu have there been complete surveys conducted with the end-users to gain understanding into the impact of the project. The design of the GHP project seems like it will cover post-installation analysis since many of the goals are to learn from the buildings in which they will be installed. Already an economic and energy saving analysis has been conducted on the apartment building in Beijing. The results of this analysis have indicated that geothermal heat pumps are more efficient and more affordable than traditional heat systems such as coal-fired boilers. These follow up reports are useful in gaining the support of the public and as a check to make sure that the project is indeed a project that will indeed be beneficial and appropriate.

Cultural Considerations and Community Involvement

As with all projects that will be conducted in a foreign country, considerations must be given to the traditions and daily rituals of the beneficiary group. Some effort should be made to understand the mindset and history of the community in order to tailor the project appropriately. Again, as mentioned, the organizations of the Gansu project decided to subsidize some of the SHS's. The subsidies were to be paid back in installments. However, much of the population of Gansu is poor and had become accustomed to receiving handouts from the government. Some of the beneficiaries did not realize that the amount they paid for their systems was only a fraction of the real cost of the system. They believed that they were paying the full amount. Therefore the credit

system did not work in this project because much of the initial investment was not returned. This affected the revolving fund and the future PV market.

Sometimes there is not enough funding or time to properly understand the workings of the community. This is why the beneficiary community should be involved in the project as much as possible in the design, implementation and maintenance of the system. If the community has investment in the project, whether with time, labor or financially, they will be more likely to have interest in seeing that the system continues working. Also, they will have a better understanding of what will fit the community's needs and be able to help direct the project. This way the pilot project will not only succeed in supplying clean electricity to the people, it will have also involved the people who are able to spread the word about these technologies. The Tibet and GHP projects are hopefully moving in this direction. With the PV powered community center in Tibet, the villagers will be directly involved. They will be the ones maintaining the system, operating video and computer equipment. The project has been designed so that the system will provide the village with a source of income from the international market and they will have power to decide what to do with that income. With the GHP project, the main goals are to include Chinese businesses and to develop local production of systems.

To really promote renewable energy in China, the communities should be active participants.

Conclusion

Many projects have been implemented in China with successful outcomes. Sustainability issues need to be addressed in the design of pilots to improve the overall performance of the project. Reviewing these issues after the implementation of a project

is important in order to efficiently plan any future large-scale projects or work. Overall, pilot projects are a great tool to promote renewable energy. They provide valuable steps towards attaining widespread use of renewable energy in China.

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References

China-US Renewable Energy Cooperation Program: Ground-source Heat Pump Introduction. Beijing JiKe Energy New Technology Development Company, 2001.

Bianchi, Gerald. Interview. August 2, 2002.

Renné, David. Interview. June 29, 2002.

Gansu PV Rural Electrification Project Fifth Trip Report. Solar Electric Light Fund, 1998.

Gansu PV Rural Electrification Project Fourth Trip Report. Solar Electric Light Fund, 1997.

Gansu PV Rural Electrification Project Third Trip Report. Solar Electric Light Fund, 1997.

Gansu PV Rural Electrification Project Second Trip Report. Solar Electric Light Fund, 1997.

Gansu PV Rural Electrification Project: Detailed Project Plan. Solar Electric Light Fund, 1996.

Lew, Debra. "Micro-Hybrids in Rural China." *REFOCUS* (2001): 30-33.

Tu, Peter. Phone Interview. August 15, 2002.